Journal of
Biology and Today's World

Review

Impact of *Trichoderma sp*. in Agriculture: A Mini-Review

Sandesh Thapa[1*], Neha Sotang[2], Anka Kumari Limbu[1], Arpana Joshi[1]

[1]Gokuleshwor Agriculture and Animal Science College, Tribhuwan University, Kirtipur, Nepal

[2]GP Koirala College of Agriculture and Research Center, Purwanchal University, Biratnagar, Nepal

[*]Correspondence should be addressed to Thapa S, Gokuleshwor Agriculture and Animal Science College, Tribhuwan University, Kirtipur, Nepal; E-mail: sand.thapa.2056@gmail.com

Received: 2 May 2020 • Accepted: 17 May 2020

ABSTRACT

Trichoderma is one of the economically important microorganisms from farmer fields to industries. This paper focuses on the economic importance of *Trichoderma* in agricultural systems which are accessed by about 50 researches and review papers previously published. *Trichoderma* is effective to use as a biocontrol in various fungal pathogens and some of the bacterial pathogen. Five species of *Trichoderma* are reported in this paper for their different activities as a biofertilizer, biopesticide, and bioremediation. *Trichoderma viridae* is one of the most used commercialized products found in Nepal and *Trichoderma harzianum* is the fungus with a broad range of benefits in agriculture. Though the use of *Trichoderma* species is reported its commercialization and use in the farmer's field is still lacking. Thus, the focus should be given for the use of *Trichoderma* in farmers' field through Farmer field trial.

Keywords: Agrochemicals, *Bacillus subtilis*, Biopesticide, Pathogenic microorganism.

INTRODUCTION

Trichoderma is a genus of fungus belongs to family Hypocreaceae and comprises more than 100 species [1]. Among much of the *Trichoderma sp*. (*T. viridae, T. haziarum, T. atroviridae, T. asperellum*) very few are reported to be useful as a biocontrol [2]. *Trichoderma* colonizes the root surface or cortex and proliferates best when there are abundant healthy roots [3]. The use of *Trichoderma* tends to be beneficial as it is reported to reduce fertilizer dose, pesticide ration in the crop field, and enhances yield [4-7]. However, the application of the recommended dosage is required because hyper concentration leads to toxicity in foods [8].

Nowadays, pests, diseases, and chemical pollution in the agriculture field are today's serious threat affecting productivity and the sustainable nature of agriculture. The microorganisms reported have shown a significant effect on soil health [9] and crop performance [6,7,10,11]. Nepal is an Agricultural country where about 65% of total people are involved in agriculture [12]. But the major constraints like pests, diseases, insects, and their application beyond recommended dosage are affecting productivity and soil health [12,13]. However, the use of *Trichoderma sp.* in the crop field is reported to have a significant effect on yield and maintaining soil micro floral population [14]. Also, it suppresses the activity of pathogenic microorganisms by enzymatic activities [15]. Though Nepal is an agricultural country, the healthy production of agricultural products is lacking due to chemical pollution by using fertilizers, herbicides, and pesticides. Thus, this study aims at presenting the importance of different *Trichoderma* species in soil and their significance after the inoculation of effective strain in respective fields.

TRICHODERMA AND ITS INTERACTION WITH MICROORGANISM

Trichoderma sp. is used for different purposes in agriculture crop production. *Trichoderma* interacts with other microorganisms, but mainly with pathogenic fungi [1,16]. These interactions include hyperparasitism, competition, and antibiosis [17]. The competition for food, nutrients, and space by modifying environmental conditions suppressed the activity of other fungi [18]. Various literatures regarding *Trichoderma sp.* to combat with plant pathogenic microorganisms like *Rhizoctonia solani*, *Pythium ultimum*, and *Botrytis cinerea* [19]. Details of the resistance offered by *Trichoderma sp.* are presented in **Table 1**. However, the interaction of *Trichoderma viridae* with beneficial microorganisms like azotobacter, rhizobium has been reported. *Trichoderma* suppressed the activity of azotobacter in maize [10]. The combination of *T.hamatum* and host-specific Rhizobium sp of *V. mungo* found significantly effective in enhancing the growth and biochemical makeup of

V. mungo [5]. The application of *Trichoderma spp.* In soil has not only provided resistance to different fungal diseases but also has improved the nutrient and fruit quality [11,16,20,21]. The mycoparasitic also have demonstrated that these fungi produce a rich mixture of antifungal enzymes, including chitinases and β-1,3 glucanases. The genes encoding the enzymes proved to be capable of producing transgenic plants resistant to diseases and the enzymes are beneficial for biological control [16].

Table 1: Resistance offered by *Trichoderma sp.* against different pathogens.

Crops	Trichoderma	Pathogen	References
Beans	*T. asperellum*	*S. sclerotium*	[22]
	T. atroviridae	*F. graminiarum and R. solani*	[22]
Cucumber	*T.asperellum*	*Pseudomonas syringae*	[23]
	T. haumatum	*Phytophthora capsici*	[24]
Strawberry	*T. harzianum*	*S. sclerotiorum,*	[25], [26]
		R. solani,	
		Botrytis cinerea, and Mucor piriformis	
Tomato	*T. harzianum*	*Meloidogyne javanica,*	[27], [28]
		Fusarium spp	
	Trichoderma sp.	*Ralstonia sp.*	[13]
Potato	*T. viridae*	*F. oxysporium,*	[14], [28]
		Phytophthora infestans	
Maize	*T.harzianum T.viride*	*P. Notatum, R. solani, Alterneria alternata*	[29]
Mushroom	*T. viridae*	*Rhizopus stolonifer*	[30]
Rice	*T. viridae*	*R. solani*	[31]
	T. harzianum	*Fusarium spp.*	[32]
Ginger	*T. harzianum*	*P. aphanidermatum*	[33]
Grapes	*T. viridae, T. harzianum*	*Penicillum expansum, Fusarium moniliforme, B.subtilli*	[34]

TRICHODERMA AS A BIOFERTILIZER

Trichoderma is widely used as a bio-fertilizer almost for all crops with or without amendments [35]. *Trichoderma* was reported high to be used in vegetable production and was most effective in tomato [11,36]. However, a positive response was also recorded from other crops like groundnut, cotton, wheat, tobacco, Bengal gram, brinjal, sugarcane, eggplant, red gram, banana, tomato, sugarbeet, chilies, potato, soybean, citrus, cauliflower, onion, peas, and sunflower [37]. The role of *Trichoderma* in improving crop yield and performance was achieved mainly by the ability to degrade complex organic compounds present in the soil. Complex organic compounds were made available to plants in the simpler form so that it could be absorbed [20]. The so-called *Trichoderma* are either present naturally in soil or effective strain of *Trichoderma* are added to soil or inoculated in seed as per the crop (**Table 2**). The seed inoculated fungus should not be treated with chemical fungicides after inoculation and should be applied in moist soil as adequate moisture is required for its survival and multiplication [37]. However, soil application of *Trichoderma* good response has been recorded on the application of can be *Trichoderma* [6]. The requirement of chemical fertilizer rate and the *Trichoderma* with compost/ FYM or organic manure rather than industrial fertilizers [5,6,20,36,37]. is also beneficial but not as much as seed inoculated Due to the antifungal activity of *Trichoderma spp.* fungicide treatment in the soil is substituted, and also maintain soil health and sustainable farming [20].

BIOREMEDIATION BY *TRICHODERMA SP.*

The use of *Trichoderma* and some other microorganisms in soil are reported to degrade the chemical contaminants present in the soil. Bioremediation and phytoremediation in association with microbes are innovative technologies having the potential to alleviate various soil pollution problems. The genus *Trichoderma* is genetically very diverse with a variety of capabilities among various strains with agricultural and industrial significance [44]. The potential *Trichoderma* alleviates contaminants by acting upon chemicals, metal contaminants by the activity of various enzymes and improves the physical and chemical properties of soil [45,46]. Heavy metal contaminants like Ni, Cd, Zn, Pb, As has been tolerated and accumulated by *Trichoderma sp.* [45,47]. Agrochemicals application in intensive cultivation has accumulated the contaminants and degrading the soil health and crop performance. *Trichoderma* inoculation in soil has reported to degrade the chemical pollutants and make nutrients available to plants from those agrochemicals too [45]. Some of the agrochemicals bioremediation evidence has been presented in **Table 3**.

Table 2: *Trichoderma* as a biofertilizer and mode of application.

Biofertilizer	Crop	Mode of application	Yield	References
Trichoderma asperellum	Rice	Seed inoculation	Increased by 30%	[38]
T. harzianum	Mustard and tomato	Inoculation in soil	50% N and *Trichoderma* enriched increased yield by 108 and 203% over control.	[11], [36], [39]
	Cucumber	Inoculation in soil	N/A but improved fruit quality and crop growth	[40]
	Chilli	Inoculation in soil	Increase in yield by 11 q/ha than that of control(58 q/ha)	[41]
	Barley	Seed inoculation	Increase in yield by 17%	[42]
T. viridae	Wheat	Soil and seed inoculation	75.8% with NPK and by 41.8% with FYM.	[6]
	Potato	Inoculation in soil	16.25 tubers/plant than that of control 2.25 tubers/ plant	[14]
	Red beet Cabbage	Seed inoculation	Increased by 29%	[43]

Table 3: Bioremediation offered by *Trichoderma* species.

S.No	Agro-chemical category	Microorganisms	References
1.	Organophosphate pesticide dichlorvos	*T. atroviridae*	[48]
2.	PGPR in metal-contaminated soil	*T. harziunum*	[49]
3.	Pesticide-polyresistance Cyanide	*Trichoderma spp.*	[50]
4.	Soil and water pollutants	*Trichoderma spp.*	[51]
5.	Heavy metals, organometallic compounds, agrochemicals, tannery effluents, and harmful chemicals like cyanide	*Trichoderma spp.*	[52]
6.	Agrochemicals viz. DDT, dieldrin, endosulfan, Penta-chloro-nitro-benzene, and Penta-chloro-phenol	*T. harziunum*	[53]
7.	Chlorpyrifos and photodieldrin (pesticides)	*T. harziunum*	[54]

CONCLUSION

Trichoderma is one of the beneficial micro-organisms in the agro-ecosystem which influences soil health and crop performance. Its antagonistic feature with plant pathogenic micro-organisms makes it more reliable for use in the agriculture field. However, its use is not limited to anti-pathogenic activity but also acts as bio fertilizer, plant growth promoter, bioremediation, and increase in crop yield both biological and economic yield. Thus, the use of *Trichoderma* should be promoted as it promises for sustainable agriculture by reducing the use of harmful chemicals in the agriculture field.

REFERENCE

1. Druzhinina IS, Kopchinskiy AG, Kubicek CP. The first 100 Trichoderma species characterized by molecular data. Mycoscience. 2006; 47(2):55-64.
2. Haque MM, Haque MA, Ilias G, Molla AH. Trichoderma- Enriched Biofertilizer: A Prospective Substitute of Inorganic Fertilizer for Mustard (Brassica campestris) Production. Agric. 1970; 8(2):66-73.
3. Hermosa R, Viterbo A, Chet I, Monte E. Plant-beneficial effects of Trichoderma and of its genes. Microbiology. 2012; 158(1):17-25.
4. Trichoderma: A bio-control agent for management soil born diseases | Agropedia. 2020.

5. Badar R, Qureshi SA. Comparative effect of Trichoderma hamatum and host-specific Rhizobium species on growth of Vigna mungo. J Appl Pharm Sci. 2012; 2(4):128-132.
6. Mahato S, Bhuju S, Shrestha J. Effect of Trichoderma Viride As Biofertilizer on Growth and Yield of Wheat. Malaysian J Sustain Agric. 2018; 2(2):1-5.
7. Samia Ageeb Akladious. Application of Trichoderma harziunum T22 as a biofertilizer supporting maize growth. African J Biotechnol. 2012;11(35):8672-8683.
8. Druzhinina IS, Komoń-Zelazowska M, Kredics L, Hatvani L, Antal Z, Belayneh T, et al. Alternative reproductive strategies of Hypocrea orientalis and genetically close but clonal Trichoderma Iongibrachiatum, both capable of causing invasive mycoses of humans. Microbiology. 2008; 154(11):3447-3459.
9. Kumar A, Bahadur I, Maurya BR, Raghuwanshi R, Meena VS, Singh DK, et al. Does a plant growth promoting rhizobacteria enhance agricultural sustainability? J Pure Appl Microbiol. 2015; 9(1):715-724.
10. Mahato S, Neupane S. Comparative study of impact of Azotobacter and Trichoderma with other fertilizers on maize growth. J Maize Res Dev. 2018; 3(1):1-16.
11. Molla AH, Manjurul Haque M, Amdadul Haque M, Ilias GNM. Trichoderma-enriched biofertilizer enhances production and nutritional quality of tomato (Lycopersicon esculentum Mill.) and minimizes NPK fertilizer use. Agric Res. 2012; 1(3):265-272.
12. Pandey N, Adhikhari M, Bhantana B. Trichoderma and its prospects in agriculture of Nepal: An overview. Int J Appl Sci Biotechnol. 2019; 7(3):309-316.
13. Ramesh GC, Pandey BR. Evaluation of Trichoderma spp. Pseudomonas fluorescens and Bacillus subtilis for biological control of Ralstonia wilt of tomato Shiva. Yendyo Referee Status. 2018; (0):1-22.
14. Susiana P, Achmadi P, Retno PS, Rina SK, Kadarwati B. The resistance of potatoes by application of Trichoderma viride Antagonists Fungus. E3S Web Conf. 2018; 73.
15. Vinale F, Sivasithamparam K, Ghisalberti EL, Marra R, Woo SL, Lorito M. Trichoderma-plant-pathogen interactions. Soil Biol Biochem. 2008; 40(1):1-10.
16. Harman GE. Overview of mechanisms and uses of Trichoderma spp. Phytopathology. 2006; 96(2):190-194.
17. Błaszczyk L, Siwulski M, Sobieralski K, Lisiecka J, Jędryczka M. Trichoderma spp. -Application and prospects for use in organic farming and industry. J Plant Prot Res. 2014; 54(4):309-317.
18. Benítez T, Rincón AM, Limón MC, Codón AC. Biocontrol mechanisms of Trichoderma strains. Int Microbiol. 2004; 7(4):249-260.
19. Brunner K, Zeilinger S, Ciliento R, Woo SL, Lorito M, Kubicek CP, et al. Improvement of the Fungal Biocontrol Agent. 2005; 71(7):3959-3965.
20. Khan MY, Haque MM, Molla AH, Rahman MM, Alam MZ. Antioxidant compounds and minerals in tomatoes by Trichoderma-enriched biofertilizer and their relationship with the soil environments. J Integr Agric. 2017; 16(3): 691-703.
21. Fiorentino N, Ventorino V, Woo SL, Pepe O, De Rosa A, Gioia L, et al. Trichoderma-based biostimulants modulate rhizosphere microbial populations and improve N uptake efficiency, yield, and nutritional quality of leafy vegetables. Front Plant Sci. 2018; 9:1-15.
22. Calin M, Raut I, Liliana M, Capra L, Gurban AM, Doni M, et al. Applications of fungal strains with keratin: Degrading and plant growth promoting characteristics. Agronomy. 2019; 9(9).
23. Shoresh M, Yedidia I, Chet I. Involvement of jasmonic acid/ethylene signaling pathway in the systemic resistance induced in cucumber by Trichoderma asperellum T203. Phytopathology. 2005; 95(1):76-84.
24. Khan J, Ooka JJ, Miller SA, Madden L V, Hoitink HAJ. Systemic resistance induced by Trichoderma hamatum 382 in cucumber against phytophthora crown rot and leaf blight. Plant Dis. 2004; 88(3):280-286.
25. Dolatabadi KH, Goltapeh EM, Varma A, Rohani N. In vitro evaluation of arbuscular mycorrhizal-like fungi and Trichoderma species against soil borne pathogens. J Agric Technol. 2011; 7(1):73-84.
26. Hjeljord LG, Stensvand A, Tronsmo A. Effect of temperature and nutrient stress on the capacity of commercial Trichoderma products to control Botrytis cinerea and Mucor piriformis in greenhouse strawberries. Biol Control. 2000; 19(2):149-160.
27. Sharon E, Bar-Eyal M, Chet I, Herrera-Estrella A, Kleifeld O, Spiegel Y. Biological control of the root-knot nematode Meloidogyne javanica by Trichoderma harzianum. Phytopathology. 2001;91(7):687-693.
28. Zope V, Jadhav H, Sayyed R. Neem cake carrier prolongs shelf life of biocontrol fungus Trichoderma viridae. Indian J Exp Biol. 2019; 57(05):372-375.
29. Bhandari C, Vishunavat K. Screening of different isolates of Trichoderma harzianum and Pseudomonas fluorescens against Fusarium moniliforme. Pantanagar J Res. 2013; 11(2):243-247.
30. Pokhar R, Pinki S, Dodiya N, JA-J. Evaluation of fungicides, neem bio-formulations and biocontrol agent for the management of root rot of safed musli caused by Rhizoctonia solani. J Mycol Plant Pathol. 2013; 43(3):297-305.
31. Bhat K, Anwar A. Research AW-PD, 2009 undefined. Evaluation of bio-control agents against Rhizoctonia solani Kuhn and sheath blight disease of rice under temperate ecology. Plant Dis Res. 2009; 24(1):15-18.
32. Sarojini C, Nagamani A. Antagonistic ability against Rhizoctonia solani and pesticide tolerance of Trichoderma strains. Adv Environ Biol. 2011; 2631-2639.
33. Gupta Yashwant Singh Parmar M. Effect of microbial inoculants on rhizome disease and growth parameters of ginger Biomanagement of fungal diseases of crop plants View project Fungal-Plant Interactions View project. Indian Phytopathol . 2010; 63(4):438-441.
34. Senthil R, Prabakar K, Rajendran L, Karthikeyan G. Efficacy of different biological control agents against

major postharvest pathogens of grapes under room temperature storage conditions. Phytopathol Mediterr. 2011; 50(1):55-64.

35. Sandle T. Trichoderma. Encycl Food Microbiol Second Ed. 2014; 644-646.
36. Haque MM, Ilias G, Molla A. Impact of Trichoderma-enriched Biofertilizer on the growth and yield of Mustard (Brassica rapa L.) and Tomato (Solanum lycopersicon Mill.). Agric. 2012; 10(2):109-119.
37. Kamal RK. Trichoderma: a Most Common Biofertilizer with Multiple Roles in Agriculture. Biomed J Sci Tech Res. 2018; 4(5):4136-4137.
38. Doni F, Zain CRCM, Isahak A, Fathurrahman F, Anhar A, Mohamad WNW, et al. A simple, efficient, and farmer- friendly Trichoderma-based biofertilizer evaluated with the SRI Rice Management System. Org Agric. 2018; 8(3): 207-223.
39. Haque M, Ilias AHGNM, Molla AH. Trichoderma-Enriched Biofertilizer: A prospective substitute of inorganic fertilizer for mustard (Brassica campestris) production. 2011;8(2):66-73.
40. Gu X, Chen W, Cai F, Pang G, Li R. Effect of Trichoderma biofertilizer on continuous cropping cucumber cultivation with reduced rates of chemical fertilizer application. Acta Pedol Sin. 2016; 53(5): 1296-1305.
41. Kumar A, Patel A, Singh S, Tiwari R. Effect of Trichoderma spp. in plant growth promotion in Chilli. Int J Curr Microbiol Appl Sci. 2019; 8(3):1574-1581.
42. Ghasemkheylif taghavi, Piradasthi h, Bahmanyar M, Tajik G. SID.ir | The Effect of Trichoderma Harzianum and Cadmium on Tolerance Index and Yield of Barley (Hordeum Vulgare L.). J Crop Ecophysiol (Agriculture Sci [Internet]. 2015; 8(4):465-481.
43. Topolovec-Pintaric S, Zutic I, Dermic E. Enhanced growth of cabbage and red beet by Trichoderma viride. Acta Agric Slov. 2013; 101(1):87-92.
44. Tripathi P, Singh PC, Mishra A, Chauhan PS, Dwivedi S, Bais RT, et al. Trichoderma: A potential bioremediator for environmental cleanup. Clean Technologies and Environmental Policy. Springer. 2013; 15:541-550.
45. López Errasquín E, Vázquez C. Tolerance and uptake of heavy metals by Trichoderma atroviride isolated from sludge. Chemosphere. 2003; 50(1):137-143.
46. Hasan S. Bioremediation: A review. 2016; 3(9):776-779.
47. Tripathi P, Singh PC, Mishra A, Chauhan PS, Dwivedi S, Bais RT, et al. Trichoderma: A potential bioremediator for environmental cleanup. Clean Technol Environ Policy. 2013; 15(4):541-550.
48. Tang J, Liu L, Huang X, Li Y, Chen Y, Chen J. Proteomic analysis of Trichoderma atroviride mycelia stressed by organophosphate pesticide dichlorvos. Can J Microbiol. 2020; 56(2):121-127.
49. Adams P, De-Leij FAAM, Lynch JM. Trichoderma harzianum Rifai 1295-22 mediates growth promotion of crack willow (Salix fragilis) saplings in both clean and metal-contaminated soil. Microb Ecol. 2007; 54(2):306-313.
50. Kredics L, Antal Z, Hatvani L. Investigation of Trichoderma strains isolated from winter wheat rhizosphere. 2004.
51. Hatvani L, Manczinger L, Kredics L, Szekeres A, Antal Z, Vágvölgyi C. Production of Trichoderma strains with pesticide-polyresistance by mutagenesis and protoplast fusion. Antonie van Leeuwenhoek. Int J Gen Mol Microbiol. 2006; 89(3-4):387-393.
52. Harman GE, Lorito M, Lynch JM. Uses of Trichoderma spp. to alleviate or remediate soil and water pollution. Adv Appl Microbiol. 2004; 56:313-330.
53. Katayama A, Matsumura F. Degradation of organochlorine pesticides, particularly endosulfan, by Trichoderma harzianum. Environ Toxicol Chem. 1993; 12(6):1059-1065.
54. Tabet JCK, Lichtenstein EP. Degradation of [14C] photodieldrin by Trichoderma viride as affected by other insecticides. Can J Microbiol. 1976; 22(9):1345-1356.